GROUP OF EIGHT AUSTRALIA

Curated:

Go8 Defence Capability 2019

THE UNIVERSITY OF WESTERN AUSTRALIA
MONASH University
Australian National University
THE UNIVERSITY of ADELAIDE
THE UNIVERSITY OF MELBOURNE
UNSW SYDNEY
THE UNIVERSITY OF QUEENSLAND AUSTRALIA
THE UNIVERSITY OF SYDNEY

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Introduction

As Group of Eight (Go8) Chief Executive I take great pride in presenting to you the curated Defence Capability of the eight Go8 members, released in conjunction with the "Go8 Defence Summit" hosted by Go8 member the University of Adelaide on 9 April 2019.

The Go8 is comprised of Australia's leading research-intensive universities. Seven of our eight members are ranked in the world's top 100 universities – no mean feat in a nation of just 25 million people. Only the US and the UK can best this result.

Over 99 per cent of the Go8's research is ranked as world class or above. While research is at our heart, we are far more. With an ethos of quality and a commitment to excellence, we deliver Australia some 100,000 quality graduates each year; the leaders of tomorrow.

The Go8, because of its consistent global results and reputation has built strong working relationships with all sectors within the large area that is known by that amorphous word "Defence".

But we want to do so much more, and we want to ensure we work to have Defence better understand, have more visibility of, what we can provide.

Communication is key and while it is excellent, we recognise it can be far better than currently exists; hence the Defence Summit which comprises representatives of our Defence partners, industry, our researcher and our commercialisation teams.

From working with Defence to educate and train its graduate entry, we are also involved with workforce planning. We understand the Defence emphasis on having access to the right graduates for its needs, now and into the future.

We also well understand the Defence emphasis on being able to work with our research teams; and that has always begun with knowing what research capability and support was available.

We are not afraid to say we are home to the best – and proud to be so.

Being the best, striving never to be anything less, has enabled the Go8 to build solid Defence research partnerships, and problem solving and advisory relationships, around the world with Governments and industry.

We are a trusted partner, and we have been at the forefront of globally-defining Defence and Security technology and systems advances for many decades.

This curated capability statement sets out who within the Go8 can help and what we do.



Vicki Thomson
Go8 Chief Executive



Being the best, striving never to be anything less, has enabled the Go8 to build solid Defence research partnerships, and problem solving and advisory relationships, around the world with Governments and industry.

The University of Adelaide

The University of Adelaide contact point:

Professor Michael Webb
Director Defence and Security

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Skills and capability

The university has a proud history of defence sector collaboration. It has worked extensively with both the Department of Defence and defence industry to assist with workforce needs, to provide specialised capabilities, and high-quality, collaborative, research programs combined with extensive experience in transitioning research into practice.

Defence stakeholders include:

- DST
- Vice Chief of the Defence Force Group
- Defence Chief Information Officer Group (CIOG), Deputy Secretary Capability Acquisition and Sustainment Group (CASG), Australian Geospatial-Intelligence Organisation (AGO), Australian Signals Directorate (ASD)
- US Air Force Office of Scientific Research (AFOSR)
- Direction générale de l'armement, France
- BAE Systems Australia
- Lockheed Martin Australia

- Boeing Defence Australia
- Dassault-Systèmes
- Australian Submarine Corporation
- Naval Group (France)

The university is also a key member of the South Australia's Defence Innovation Partnership.

Research strengths

Photonics & Advanced Sensing

- Precision Clocks underpinning significant advances in radar capability (Professor Andre Luiten)
- Optical Material and Optical Fibre Sensing for sensing and fibre laser applications (Professor Heike Ebendorff-Heidepriem)
- Novel radiation detection capabilities (A/Professor Nigel Spooner)
- Standoff materials identification for explosives sensing (A/Professor Nigel Spooner)

Machine Learning & Artificial Intelligence

- AI for Autonomous Systems to analyse sensor data and robot control (Professor Anton van den Hengel)
- Intelligence, Surveillance and Reconnaissance (Professor Anton van den Hengel)

Cyber Security

- Side-channel attacks and computer hardware limitations (Dr Yuval Yarom)
- Provable Network Security (Dr Hung Nguyen)
- Human Aspects of Cyber Security (Dr Malcolm Pattinson)
- Cybercrime and Digital Forensics (Dr Matthew Sorell)

Distributed Software Systems

- Complex Systems (Dr Claudia Szabo)
- Mission Critical Systems (Professor Ali Babar)

Defence Communications & Networking

- Defence Communications Modelling and Simulation (Dr Matthew Britton)
- Combat System Modelling (Dr Matthew Britton)

The University of Adelaide

Distributed Multi-Agent Control

- Swarm Intelligence (Professor Cheng-Chew Lim)
- Autonomous Multi-Robot Systems for UAVs (A/Professor Steven Grainger)

Acoustics, Vibration & Control

- Submarine signature management (Professor Carl Howard)

Graphene Research

- Enabled industry transformation, including electromagnetic and acoustic shielding (Professor Dusan Losic)

Chemical, biological, radiological incident response

- Risk and evidence-based decision-making on HAZMAT decontamination (Professor Dino Pisaniello)

Applied Electromagnetics

- Including Antenna engineering and microwave passive components (Professor Christophe Fumeaux)

Physics Inspired Tracking

- Probability density function of a target position and velocity (Professor Anthony Thomas)

Pain blood test to assess psychology stress to an individual's state of resilience

Radar & Ionospheric Physics

- Detection, radar imaging, GPS systems, passive radar systems, etc. (Dr Brian Ng)
- Ionospheric Physics relating to space situational awareness (Dr Andrew MacKinnon)

Directed Energy

- Cryogenic solid-state laser approach (Professor Peter Veitch)

Sonar Sensor Array Signal Processing

- Signal processing for sonar and operational systems (Professor Lang White)

Structural Health Monitoring

- Including state-of-art ultrasonic guided wave excitation and measurement systems (A/Professor Andrei Kotousov)

Nanoscale BioPhotonics

- Pain blood test to assess psychology stress to an individual's state of resilience (Professor Mark Hutchinson)
- Light-based neuronal control for human machine interfaces (Professor Mark Hutchinson)

Visual Physiology & Neurobotics

- Bio-inspired autonomy (Dr Steven Wiederman)

Human Factors

- Brain and cognition factors in Defence contexts (A/Professor Anna Ma-Wyatt)

Military Law & Ethics

- Legal and policy issues relevant to military and security matters (Professor Dale Stephen CSM)
- International Space Law, "The Woomera Manual" (Professor Dale Stephen CSM)
- Operational Commercial Law (Dr Colette Langos)

Traumatic Stress Studies

- Military health surveillance research, including bio-stress markers (Professor Sandy McFarlane)

Social Media Analytics

- Information dynamics on networks and topic modelling (Dr Lewis Mitchell)

Research infrastructure

In partnership with Government and industry the University has established a number of world-class research institutes and centres to tackle state and national research priorities.

Research infrastructure includes:

- The Institute for Photonics and Advanced Sensing (IPAS) with capabilities in the design, fabrication and implementation of disruptive measurement technologies
- OptofabNode, an Australian National Fabrication Facility – the leading speciality glass and optical fibre fabrication facility in Australia for sensing and fibre laser applications

- The Prescott Environmental Luminescence Laboratory with world-leading radiation detection and measurement capabilities for population radiation exposure, and forensic analysis of clandestine radiological sites
- The Visual Physiology and Neurobotics Laboratory investigates visual processing from behavioural, computational and physiological levels, with a multidisciplinary team covering neuroethology, neurobiology, psychology, computer vision and engineering
- The Australian Institute for Machine Learning infrastructure, e.g. Visual Simultaneous Localisation and Mapping
- High-Performance Computing with a 'Phoenix' supercomputer with storage capacity of 700 terabytes and processing speed up to 450 teraflops
- A Distributed Multi-Agent Control laboratory
- High-powered laser laboratory (for Directed Energy research)
- Centre for Nanoscale Biophotonics laboratories
- Graphene Industry Transformation Hub

Collaborations

The University of Adelaide collaborates with defence organisations and defence industries:

Sapphire Clock

High Frequency and Phased Array Radars have been identified by Defence as a priority industry capability. 20 years of leading-edge fundamental research and cutting-edge engineering, have delivered a disruptive technology to revolutionise the Jindalee Over-The-Horizon Radar Network (JORN). This key defence surveillance asset could be significantly enhanced by incorporating the Sapphire Clock; developed by the university's Institute for Photonics and Advanced Sensing. The Sapphire Oscillator (or Sapphire Clock) offers performance more than 1000 times better (in the relevant ranges) than the current JORN

technology. Defence has invested more than $4 million. The technology also has potential benefits to ship-based phased-array radar and a smaller and less expensive solution is being developed for this much larger market.

Autonomous robot platform

Using behavioural, electrophysiological and morphological techniques, Medical Sciences researchers have developed computational models that provide robust and efficient solutions to target-detection and tracking. This autonomous robot platform detects, selects and pursues moving features in cluttered environments. The multidisciplinary collaboration across neurosciences, psychology, engineering and computer vision was established in collaboration with Lund University and San Diego State University, and based on a $10 million investment by the US Air Force Office of Scientific Research. The work is also contributing to Next Generation Technologies Fund projects, including the Grand Challenge of Countering Improvised Threats.

Lockheed Martin Australia

Lockheed Martin Australia is the first Foundation Partner with the university's Australian Institute for Machine Learning (AIML). The strategic partnership will deliver world-leading machine learning research for national security, the space industry, business, and the broader community. Lockheed Martin Australia will have a research team co-located in Adelaide.

Dassault Systèmes

Dassault Systèmes is to establish its South Australian regional centre at the university. It will have an Adelaide-based team comprising staff from France and India, and will host university interns.

Key personnel

Key contacts are:

Professor Michael Webb
Director, Defence and Security

Professor Bruce Northcote
Pro Vice-Chancellor,
Research Engagement

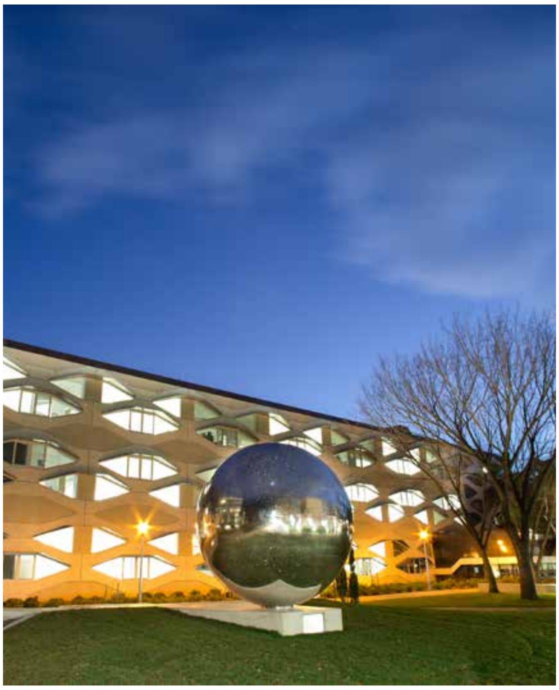
The Australian National University (ANU)

ANU contact point:

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Skills and capability

The Australian National University (ANU) has broad expertise applicable to Defence research – the physical and mathematical sciences, chemistry, biological and health sciences, earth science, environmental sciences, psychology and engineering. There are also strong arts and humanities research and teaching programs that can provide key input into complex defence problems using deep knowledge of culture, history, languages, geography and geopolitics.

The university also has expertise via the Strategic and Defence Studies Centre and the National Security College as well as with the Australian Signals Directorate, through an on-campus collaboration in research and training to build domestic STEM capability. The Master of Military and Defence Studies is another example of ANU-Defence collaboration through the Australian Command and Staff College of the Australian Defence Force.

ANU also has the capability to bring diverse expertise together to form

groups capable of addressing complex or wicked Defence problems that may benefit from areas as disparate as the humanities, strategic studies, science and engineering.

Through the ANU Defence Working Group, ANU is refining its engagement mechanisms and is in the process of streamlining access to ANU expertise.

Research strengths

ANU boasts several areas of strengths in defence research, including:

3A Institute
Professor Genevieve Bell

The Institute is researching critical questions around Autonomy, Agency and Assurance for cyber-physical systems (CPS). It is developing an intellectual framework for designing, building, managing, scaling and decommissioning AI-enabled technologies that have converged into CPS. It is prototyping the first curriculum in this new applied science. This includes a student who is a serving member of the Defence Force seconded to the project

Humanising Machine Intelligence (MI)
Professor Seth Lazar

The university has a significant cross-disciplinary program across computer science, philosophy and sociology. It involves Government, Civil Society, Industry and Academia to design more ethical MI systems – by incorporating moral values into machine decision-making, to ensure efficiency gains do not come at an unacceptable moral cost

Trusted Autonomous Systems
Professor Jochen Renz;
Professor Hanna Kurniawati

The AI group in the Research School of Computer Science is developing mathematical principled frameworks for robotics and designing the associated software implementation. The algorithms quantify uncertainty, rather than exaggerate risks, and adapt the system's strategies in real-time, based on additional and/or lack of additional information, taking into account errors in sensors and sensing. The algorithms are being designed for large-scale decision making in unpredictable physical and non-physical environments

The Australian National University (ANU)

Cyber

Dr Lesley Seebeck

- Cybersecurity and statecraft
- Cyber criminology and regulation
- Legal and statutory interpretation of terrorism, cybercrime and cyberwarfare
- Network science, social network analysis and cyber social research methods
- Formal methods, computer security, data analytics and physical layer security for the internet of things

Quantum Technologies

- Capability to generate ultra-high bitrate unbiased random numbers, and encrypt, store and process quantum data with absolute security (Professor Ping Koy Lam, Professor Matthew Sellars)
- Capability in quantum inertial sensing and quantum gravimetry (Professor John Close)
- Optical and infrared imaging and communication, space debris monitoring and removal techniques (Professor Anna Moore, Dr Francis Bennet)

Materials projects

- Next generation additive manufacture in flow, explicitly directed at producing energetic materials with a spatial functional gradient (Professor Nicholas Kanizaj)
- Photochemical enhancement of the energy content of renewable hydrocarbons for generation of high-energy fuels for marine, terrestrial and aerospace application, coupled with the expertise in synthetic biology to optimise production of the terpenoid feedstock for such a process (Professor Michael Sherburn)
- Functional solid-state nanopore-membranes for chemical and bio-sensors (A/Professor Patrick Kluth)

Research infrastructure

- The National Security College (NSC) is a joint initiative of the Australian Government and ANU, established to address significant national security policy questions and challenges that confront Australia, the Indo-Pacific region and the world. Specific research capacity is generated in:

» counterterrorism and countering violent extremism

» cyber security

» security futures (including the intersection of policy, global change and technology)

» national security policy and practice

- The Strategic & Defence Studies Centre (SDSC) is Australia's largest body of scholars dedicated to the analysis of the use of armed force in its political context
- The ANU Cyber Institute has been established to take a deep and long-term perspective on cyber research and activity
- Defence Science Technology (DST) investment in the National Space Test Facilities hosted at Mount Stromlo
- The ANU Nonlinear Physics Centre works with the ANFF to fabricate and characterise a microelectromechanical system-based material – developing a unified technology to manipulate infrared and terahertz waves. The Centre also works with the ANFF and NCI to fabricate and embed nanocrystals into glass
- Other National facilities:

» National Computational Infrastructure

» Australian National Fabrication Facility (NCRIS funded)

Collaborations

In addition to close collaborations with defence government partners such as ASD and companies such as Lockheed Martin, Northrop Grumman, Thales and Airbus, the university has invested in several strategic partnerships, both from a research and commercialisation aspect.

DST

- DSTG SEA1000 AO – development of an adaptive optics system for a 0.5 m telescope for optical communications
- Defence Next Generation Technologies Fund (NGTF) – demonstration of free-space quantum key distribution (QKD) with adaptive optics
- Quintessence Labs – space qualification of quantum technology and quantum repeater architecture with DST-G

The Australian National University (ANU)

- Cyber NGTF – Mounting "simulated" attacks on networked systems to find weaknesses is an important tool in cyber security evaluation and defence. The project aims to automate some aspects of this using AI planning techniques

DLR – German Aerospace Centre

- QUOLLSat Mission – Aims to develop technology which enables a global quantum secure network with commercial applications. Partners include CSIRO, Tesat, NASA Jet Propulsion Laboratory (JPL), DST, National Institute of Information and Communications Technology (NICT) Japan
- Free-space quantum memory demonstration – expanding on Defence NGTF funding aims to demonstrate quantum communication between two remote sites using adaptive optics and quantum memory, as a stepping stone to the QUOLLSat mission

The Carnegie Corporation of New York

Strategic stability and submarine detection technology.

- Two-year grant awarded to the ANU NSC to explore the interaction of new technologies, maritime security, submarines and nuclear strategy in the Indo-Pacific

Key personnel

Professor Anna Moore Director InSpace Innovation Institute
– Space Lead

A/ Professor Colin Jackson Research School Of Chemistry
– Cell-Free Protein Production And Detection

Professor Daniel Shaddock Group Lead, Space Instrumentation
– Optical Interferometry

Dr Francis Bennett Research School Of Astronomy & Astrophysics
– Secure Global Quantum Communication Network

Professor Genevieve Bell, Director 3A Innovation Institute – AI Lead

Australian National University

Professor Jochen Renz Head Artificial Intelligence Group – Trusted Autonomous Systems

Professor John Blaxland Head Strategic And Defence Studies Centre – Intelligence And Analysis Of The Use Of Armed Force In Its Political Context

Professor John Close Head, Defence Working Group – Quantum Sensors

Dr Jong Chow Group Lead Advanced Sensing – High Performance Sensing

Professor Ken Baldwin Head Energy Change Institute – Energy Change

Professor Lachlan Blackhall Head Battery Storage And Grid Integration Program – Battery Storage

Professor Lesley Seebeck CEO Cyber Institute – Cyber Lead

Professor Mark Knackstedt Director ARC Training Centre For 3D Imaging – Modelling & Manufacturing Non-Destructive Evaluation Technology For Additive Manufacturing Processes

A/ Professor Matthew Sellars Laser Physics Centre – Optical Quantum Processors And Quantum Memories

Professor Michael Sherburn Research School Of Chemistry Solar High-Energy Fuels

Professor Ping Koy Lam Director ARC Centre For Quantum Computer And Communication Technology – Quantum Optics

Professor Rory Medcalf Head National Security College – National Security Policy

Professor Sharon Dean Chief Operating Officer National Security College – On Secondment From The Office Of National Assessments

Professor Sylvie Thiebaux Associate Dean Research Research School Of Computer Science – AI-Based Control To Enhance Electric Grid Resilience

Professor Tim Senden Director Research School Of Physics And Engineering – Imaging Technology For Oil And Gas Exploration

Professor Brendan Sargeant Strategic and Defence Studies – Security Policy/Intelligence

The University of Melbourne

The University of Melbourne contact point:

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Skills and capability

As a globally engaged, comprehensive research institution, The University of Melbourne works closely with government and industry partners to deliver use-inspired research outcomes to its defence stakeholders in Australia and overseas. There is significant emphasis on progressing cross-disciplinary, translational research in emerging fields of defence capability priority, such as advanced multifunction antennas and sensor systems, trusted autonomous systems, medical countermeasures, enhanced human performance, quantum sensors, maritime and aerospace technologies, cyber, intelligence analytics and artificial intelligence.

The university has established a cross-faculty defence research enterprise that has collaborative research relationships with large defence firms and several small-and-medium enterprises to deliver novel and high technology solutions to complex defence problems. It has a long history of collaboration with Defence Science and Technology

Group, other leading universities and industry with the Next Generation Technology Fund.

The university fosters a strong engagement with US Defence agencies and leverages its Australian Research Council (ARC) funded and US Defence program with Australian defence use-inspired research projects.

Research strengths

The university's research has directly impacted defence and national security fields including advanced materials for the blast protection of army vehicles and embassies, drag reduction of ships and submarines, helicopter landings on ships in high seas, radar tracking and adaptive radar and sonar systems for a number of major defence projects.

The university fosters a strong engagement with US Defence agencies ...

It has an international reputation in metocean and maritime research using unique research infrastructure including the world's largest wind-water interface, a high Reynolds number wind tunnel, and ice-structure interaction tanks.

The university's defence science portfolio provides a breadth of insight and expertise to analyse technological challenges, conceptualise solutions and rigorously evaluate outcomes and provide robust industry-ready solutions.

The portfolio includes:

Trusted Autonomous Systems
Professor Chris Manzie

Distributed agent control and multi-modal autonomous systems. Human-centric autonomy and how humans interact with autonomous systems. Artificial intelligence including planning and adaptive networks

Enhanced Human Performance
Professor Peter Lee

Injury prevention, biomechanical, cognitive and physiological modelling and testing of soldiers and military personnel and their associated systems and personnel protection. Developing a virtual soldier for advanced testing and development

The University of Melbourne

Medical Countermeasures
Professor Sharon Lewin, Professor Michael Parker, Professor James McCaw

Chemical and biological threat detection and mitigation. Health preparedness, emergency response, epidemiology for disease surveillance and management, vaccines, point of care testing, drug discovery, synthetic biology, bioinformatics, environmental modelling and monitoring

Multidisciplinary Materials
Professor Graham Schaffer

Integrated Computational Materials Engineering, functional materials for ballistics protection and signature management. Novel materials for hypersonic platforms, maritime and aerospace applications including advanced composites, metals and polymers

Power and Energy
Professor Michael Brear

Smart grid technology for ships and forward deployed forces. Optimising diesel engines and diesel performance for submarines. Alternative power and energy sources including hydrogen-based fuel cells

Maritime Research
Professor Jason Monty

Wave-structure interaction including world class experimental facilities. Turbulence and cavitation research. Drag reduction for ships and submarines. Hydrodynamic modelling and metocean research

Aerospace Research
Professor Ivan Marusic

Drag reduction, acoustic modelling and testing, turbulence modelling, computational fluid dynamics modelling and high Reynolds number experimental facilities

Quantum Technology
Professor Lloyd Hollenberg

Nitrogen vacancy diamond based sensors, quantum computers, quantum sensing for gravitometers and magnetometers. Quantum computer modelling, quantum software engineering. Quantum mathematics

Radar and Signal Processing
Professor Rob Evans

Antenna technology, adaptive radar, adaptive electronic warfare sensing.

Waveform design, multibeam synthesis, optimal antenna synthesis for phased arrays. Electromagnetic modelling

Sensor and Information Processing
Professor Bill Moran

Sensor design, tracking, detection, matched filtering, optimal signal processing, dynamic stochastic control and networked sensor systems. Passive and active sonar signal processing and tracking. Dynamic resource allocation and sensor scheduling

Cyber Defence Systems
Professor Chris Leckie

Big data analytics, control systems, cyber defence, security monitoring, incident response and risk assessment

Intelligence Analytics
Professor Shanika Karunasekera,
Dr Tim Van Gelder, Dr Richard De Rozario

Big data, data stream analysis, social network analysis, data mining, synthesis of decision-making and amalgamation of decisions. Crowd sourcing intelligence analysis, intelligence and cloud computing

Artificial Intelligence
Professor James Bailey

Natural language processing, explainable AI, machine learning, adversarial machine learning, deep learning, data science, evolutionary computation, theory of mind, natural language processing

Research infrastructure

- Maritime and Aerospace Research Infrastructure, a world class ocean simulator 60m tunnel (Extreme Air-Sea Interaction Facility), Sea-ice-wave interaction facility, high Reynolds number wind tunnel
- Melbourne Energy Institute, a smart grid hardware-based simulator, gas turbines, optical engine, constant volume chamber, plug flow reactor, transient engine dynamometer and emission facility, octane rating engine
- Medical Countermeasure, 3-D printing of materials, medical and bioengineering laboratories, microfluidic analysis, (point of care testing), X-ray crystallography, NMR, mass spectroscopy, proteomics

- Enhanced Human Performance, Australian-first state of the art Virtual Reality biomechanical facility to improve the understanding of human movement and how to treat and prevent injuries. Used to predict soldier performance in various scenarios
- The university's Fishermans Bend campus will be situated beside Defence Science and Technology Group and next to several major defence industries. The campus is a $900 million investment and includes world class water tanks, wind tunnels and autonomous systems laboratories. More than 1000 engineering and IT students and academics will collaborate with defence industry and government there
- The university's Melbourne medical research precinct is one of the largest in the world with several institutes and research hospitals. The defence Medical Countermeasures program can draw on the research capacity and capability of this precinct

Collaborations

The university has several deep strategic partnerships with large defence firms as well as small and medium enterprises. These include:

DST

Substantial research programs in several areas

BAESystems

Control systems, autonomous systems and aerospace platform design

Lockheed Martin

Mission and intelligence, surveillance and reconnaissance systems, sensor systems, resource scheduling

Tectonica

Grand challenge project and unattended ground sensor systems

DefendTex

Electromagnetic modelling and autonomous systems

The university has a major role in the newly formed Defence CRC in Trusted Autonomous Systems and collaborates with several companies in Aerospace and Land projects

The university has significant collaborations with international universities including National Defence University, Princeton, University of Southampton, University of Rhode Island and several US Defence agencies.

Key personnel

Enterprise Professor Len Sciacca Enterprise Professor Defence Technologies

Professor Chris Manzie – Trusted Autonomous Systems Research Leader Head of Department Electrical and Electronic Engineering,

Professor Peter Lee – Enhanced Human Performance Research Leader

Professor Graham Schaffer – Multidisciplinary Materials Research Leader

Professor James Bailey – Artificial Intelligence Research Leader

Professor Adrian Pearce – Artificial Intelligence Co-Research Leader

Professor Lloyd Hollenberg – Quantum Technologies Research Leader

Professor Rob Evans – Radar and Signal Processing Research Leader

Professor Bill Moran – Sensor and Signal Processing Research Leader

Professor Sharon Lewin – Medical Countermeasures Research leader Director of Doherty Institute

Professor Michael Parker – Director Bio21 Institute

Professor Michael Brear – Power and Energy Research Leader Director Melbourne Energy Institute

Professor Ivan Marusic – Aerospace Research Leader Deputy Dean Research, Melbourne School of Engineering

Professor Jason Monty – Maritime Research Leader Head of Department Mechanical Engineering

Professor Chris Leckie – Cyber Research Leader

Professor Shanika Karunasekera – Intelligence Analytics Research Leader

Dr Richard De Rozario – Biosciences, IARPA Swarm Project

Dr Tim Van Gelder – Biosciences, IARPA Swarm Project

Monash University

Monash University contact point:

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Head of Mechanical and Aerospace Engineering

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Skills and capability

Monash University engages in defence-related research across all platforms: land, air, maritime and personnel. The university has a long history of engagement with DST Group, the RAAF, Veterans' Affairs, the Office of Naval Research – Global (ONR-G) – and directly with ONR in the US – and with the AOARD.

Engineering materials and manufacturing are significant strengths, spanning all defence platforms. Fluid – structure interactions form another significant area of capability, with multiple projects on hydrodynamics of submersed hulls; aerodynamics and turbulence combustion. These projects are both computational and experimental. Robotics, decision-making and unmanned autonomous systems all support defence efforts, as do expertise in asset management and protection, cyber security and the CAVE2 immersive visualisation environment. Medical expertise includes biomed – implants, biomaterials and imaging; research into mental health and trauma, drug

discoveries, anti-infective research, regenerative medicine and medical interventions.

The Power Engineering Advanced Research Laboratory (PEARL) has a particular focus on control and design of maritime and shipboard islanded microgrids. PEARL possesses capabilities and expertise in electrical power systems design, optimisation, monitoring, and control, and also the real-time simulation of such systems using various platforms such as RTDS and Opal RT.

In addition, the IT faculty has the largest group of data scientists of any research institution in the Asia-Pacific region. As the only designated IT faculty in an Australian University to have state-of-the-art research infrastructure on site, there is a substantial scale and high-risk tolerance to promote innovation.

Key capabilities aligned to defence include research in:

- Cybersecurity: cryptographic algorithms, including for quantum computing; trusted computing; block-chain; information privacy to users
- Modelling, Optimisation, Immersive Analytics/Visualisation, Augmented/Virtual Reality supporting decision making, particularly human-in-the-loop
- Machine Learning for surveillance, monitoring and assistance systems; behavioural modelling; information retrieval
- Artificial Intelligence: Bayesian techniques; Dialogue Research Lab dedicated to building and evaluating dialogue systems based on a variety of AI systems; User modelling

Research strengths

Metals and alloys

Research ranges from light alloys, brass to advanced steels. It is focused on thermomechanical processing, microstructural characterisation using electron microscopes and the synchrotron, evaluation of mechanical and corrosion properties, modelling of phase transformations and microstructure-property relationships, and constitutive modelling of mechanical properties of metallic materials

Monash University

Additive manufacturing

Research across the additive manufacturing value chain including engineering design, process control, alloy design and processing, surface finishing, and qualification and testing aims to stronger, lighter and more cost-effective components with improved efficiency and performance

Fluid structure interactions

Unparalleled research and testing capabilities through our horizontal and vertical test tunnels, water jet facility, wind tunnel, gas supersonic jet visualisation facility and heat jet facility. The experimental capability is complemented by direct numerical simulation of turbulence, and large-eddy simulation to predict turbulence-generated noise

Decision-making

Informed decision-making is a major determinant of mission success. The Monash Institute of Cognitive and Clinical Neuroscience (MICCN) undertakes research into how real-world decision-making can be enhanced and protected from the impact of challenging operational conditions, including sleep deprivation and circadian misalignment. It also investigates how AI, virtual and augmented reality, or brain-computer interfaces can be used to support effective decision making, automation and performing advanced reasoning



Research infrastructure

Monash University operates a network of over 30 Technology Platforms. These core facilities provide specialist interdisciplinary infrastructure, service and expertise to researchers across both academia and industry. These facilities include:

Monash Centre for Electron Microscopy (MCEM)

A world class centre for multi-scale characterisation of materials that can determine the composition, structure and bonding of materials down to the atomic scale. It researches the development and application of electron microscopy methods and provides advanced instrumentation, expertise and teaching in electron microscopy

Centre for Additive Manufacturing (MCAM)

Home to some of the world's most advanced Additive Manufacturing equipment takes fundamental research and applies it to manufacturing challenges. It works with its partners to invent bespoke solutions to unique manufacturing challenges

Be Active Sleep Eat (BASE)

Advances the science of nutrition, sleep and activity. It pioneers the integration of nutrition, sleep, exercise physiology, and physical therapy from research into practice

Multi-modal Australian Sciences Imaging and Visualisation Environment (MASSIVE)

Australia's specialised high-performance computing facility for imaging and visualisation. It provides hardware, software and expertise to drive research in biomedical sciences, materials research, engineering and geosciences – with particular focus on neuroscience and molecular imaging

Monash Wind Tunnel

Australia's leading low speed automotive aerodynamic test facility. It supports aerodynamic and wind noise research and development of full-scale production vehicles for Australian and international markets. It also provides research and development capabilities for industries

Monash University



The Monash Institute for Medical Engineering (MIME)

Focus on translational MedTech research. Clinical research areas include neuroscience and vision, cardiovascular and pulmonary and therapeutics and regenerative medicine

Monash Energy Materials and Systems Institute (MEMSI)

Develops solutions to enable sustainable generation, storage, distribution and use of energy

Monash Maintenance Technology Institute (MTI)

Provides comprehensive industry focused research and development which achieves optimum plant and equipment performance across Australia and overseas

Monash Infrastructure (MI)

Develops cutting-edge solutions to make the world's existing and new infrastructure more cost effective, smarter, resilient, productive and sustainable

The Monash Immersive Visualisation Platform (MIVP)

Operates advanced, immersive and large-scale visualisation facilities, to enable IT researchers and Defence leaders to nascent display and interaction technologies, changing the way big data is visualised and analysed

Monash Centre for Data Science

Focussed on developing effective data-driven solutions in data governance, data management and data archiving, data analytics and visualisation

Sensilab

A purpose-built research laboratory incorporating immersive visualisation systems, sound and imaging studios, fabrication areas, robotics and electronics maker spaces, integrated with advanced computing infrastructure

The Emerging Technologies Lab

Investigates an emerging technological environment where automation, AI, data and the question of ethics are increasingly central to the design of better, responsible and ethical futures

Collaborations

Monash has worked with DST and international partners to investigate factors impacting propulsion energy (e.g. Turbulent boundary layers) in sea and air defence platforms. Experimental and computational research has been directed at addressing the stealth of both moving submerged and full merged underwater vehicles and understanding the signatures produced by submarines to minimise detection.

Recent collaborations include:

IARPA CREATE

Crowdsourcing Evidence, Argumentation, Thinking and Evaluation

the university received two IARPA (Intelligence Advanced Research Projects Activity) research program grants in 2017 from the US office of National Intelligence with a combined value of US$6.1 million

Monash University

CREATE BARD Project
2017–2018

BARD (Bayesian Argumentation via Delphi) has been developed with US$5.7 million US Government funding. Lead by Monash in collaboration with three UK Universities, the BARD project focused on researching and designing new means of building and interacting with causal Bayesian networks to improve reasoning and generate causal explanations, and improve intelligence analysis

CREATE SWARM Project
2017 – present

A joint collaboration between Monash and Melbourne University and Imperial College London and Stanford University, this project conducts research into harnessing the wisdom of crowds to improve intelligence analysis

Additive Manufacturing
Powder bed fusion

aims to develop monitoring and control systems which can quantify the part variance and significantly reduce the risk of AM by applying a newly developed method of inspecting Powder Bed Fusion components in-process in real-time

In-situ health monitoring of Defence platforms in harsh environments

investigating emergent techniques for the inscription of fibre optic strain sensors through the protective coating of the fibre to achieve enhanced fibre strength and fatigue life

Advanced flow diagnostics for aeronautical research

Developed and implemented laser-based 3-dimensional multi-component velocimetry methods in aeronautical flow research

Coalition warfare program

to reduce weight and improve durability of contemporary military equipment including naval vessels, armour plate for land and air, and a number of vehicles, by utilising corrosion resistant weldable aluminium alloys that are also tough

Key personnel

Manufacturing Optimisation
Dr Andrey Molotnikov
& Professor Chris Davies

Structural health monitoring
Professor Wing Kong Chiu

Materials technology
Professor Chris Hutchinson

Hydrodynamics
Professor Julio Soria
& Dr Callum Atkinson

Computational Fluid Dynamics
Professor Murray Rudman

Energy storage
Professor Kiyonori Suzuki

Electro-Photonics
Professor Arthur Lowery

Software Defined Telecommunications
Professor Emanuele Viterbo

Microwave, Antennas / RFID and Sensors
A/Professor Nemai Karmakar

Artificial Intelligence (AI)
Professor Ann Nicholson – Bayesian and causal reasoning, intelligence decision support (both DST and IARPA)

Professor Phil Cohen – A world leading expert in artificial intelligence

Professor Ingrid Zukerman – User modelling, Natural language generation, Explainable AI (IARPA)

Machine Learning
Professor Geoff Webb – Data science, bioinformatics, data mining

Professor Dinh Phung – Deep learning, data science, representation models

Dr Francois Pettijean (ARC DECRA) – Data analysis, data modelling, earth satellite applications

Cybersecurity
A/Professor Carsten Rudolph Director Oceania Cyber Security Centre and Monash Cybersecurity Lead – Trusted computing, security protocols, digital forensics, security engineering and verification

HCI & Immersive Analytics
Professor Kimbal Marriott – Immersive analytics, optimisation, accessible graphics

Professor Sharon Oviatt – Human computer interaction, mobile and ubiquitous computing, multimodal interfaces

A/Professor Tim Dwyer – Immersive analytics, information visualisation, visual analytics

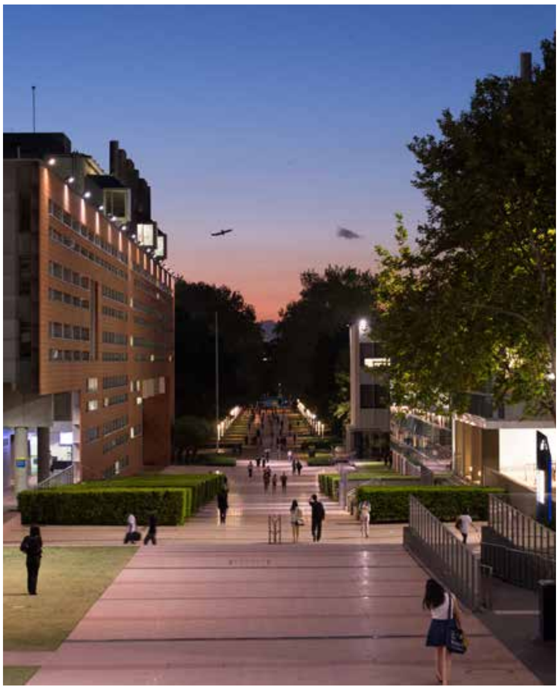
UNSW Sydney

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Skills and capability

UNSW has expertise, facilities and infrastructure in professional and scientific fields including business and management, human and social sciences, medical and health sciences, law and ethics, science and engineering, and IT and cyber.

The university has an enduring relationship with the Australian Defence Force (ADF) founded on:

- The delivery of undergraduate and postgraduate education to ADF personnel at the Australian Defence Force Academy (ADFA) for over 50 years
- Technical Staff Officer training at the Capability & Technology Management Centre (CTMC) – formerly ATSOC – since 1992
- Impactful research collaborations with ADF Services and Groups including DST Group

The university can offer its research partners:

- Broad and deep understanding of the global defence and security research context

- Access to world class researchers, technologies, and infrastructure including the T-ADFA Hypersonics Laboratory; a cyber range co-designed with CSIRO for teaching, training and research; and one of the largest UAV flight laboratories in Australia
- Access to national and global research partners including Go8 members, DST Group and the PLuS Alliance
- Dedicated organisational units – the UNSW Defence Research Institute, and UNSW Knowledge Exchange in the Division of Enterprise – are committed to leading engagement with the Defence sector across government and industry
- Highly effective collaboration mechanisms including sophisticated research strategy advice and support to maximise the impact, mutual benefit and value of research collaborations and, from 2021, a Defence and Security Innovation Precinct in Canberra

Research strengths[1]

UNSW is at, above or well above world standard in several key defence-related research areas including:

Autonomous Systems

Trusted Autonomy is a game-changing area of Defence research centred on understanding and engineering the interaction space between humans and machines. UNSW brings a combination of skills in robotics, AI, simulation and ethics with focus on trusted human-autonomy learning and cyber-physical systems.

Key Contact:

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The university has an enduring relationship with the Australian Defence Force ...

1 Read more at: www.dri.unsw.edu.au/defence-research-at-unsw/capability-portfolio.

UNSW Sydney

Communication, Quantum, Digital and Cyber

The digital domain represents an increasing and persistent threat to global stability, and an opportunity to develop leading edge digital capabilities. UNSW is a leader in a number of technology fields including quantum computation and communication technologies; cyber security, operations, law and ethics; sensors, signal processing and data fusion; IoT analysis and applications with a focus on data mining and deep learning, human activity recognition, information filtering and brain-computer interfaces.

Key Contacts:

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Centre Manager UNSW Cyber

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Hypersonics

UNSW's hypersonics capabilities include propulsion systems; high-speed free-flight test facilities; control method testing and analysis; experimentation facilities and diagnostics to test structural performance of materials and components at supersonic and hypersonic speeds; and hypersonic sensor design including optics, electronics and communication technologies.

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Space

UNSW has Australia's largest space engineering capability, able to support mission planning, and space

craft design, manufacture, testing and operation. The university has collaborated with DST Group and RAAF to successfully launch two satellites, with two more missions with committed launch contracts. Key facilities include the Australian National Concurrent Design Facility (ANCDF), supporting integrated mission conceptualisation, planning and space craft design; a Class 10,000 clean room for space craft assembly and integration; and a satellite ground station supporting space missions and space situational awareness.

Key Contacts:

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Chair for Space Engineering
UNSW Space

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A/Professor Robert Malaney School of Electrical Engineering and Telecommunications

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Research infrastructure

In addition to the facilities mentioned above, UNSW hosts the Mark Wainwright Analytical Centre (MWAC). MWAC manages major instrumentation used by researchers for the study of the structure and composition of biological, chemical and physical materials. Facilities are accessible to external researchers, government and industry users.

Please see https://www.analytical.unsw.edu.au/ for links to specific facilities including Electron Microscope Unit, Nuclear Magnetic Resonance Facility and Spectroscopy Laboratory.

UNSW hosts a number of unique defence related facilities including:

- Cyber range that provides war gaming, training and exercising co-designed with CSIRO for teaching, training and research
- One of 12 telescopes as part of the Falcon Telescope Network for monitoring fast moving space debris and satellites for space situational awareness

- The fastest two-stage gas-gun in the Southern Hemisphere, able to fire projectiles to 4.5 km/s
- T-ADFA hypersonics laboratory, a combination of a free-piston driven shock tunnel with multi-mode laser-based flow diagnostics
- One of the largest indoor UAV flight laboratories in Australia
- The most developed Mössbauer spectroscopy laboratory in Australia

Collaborations

UNSW is committed to using knowledge, capability and technology to engage with industry, government and the community. UNSW has a flexible approach to collaboration and looks to maximise value and mutual benefit for partners.

Three current examples are:

Work on metamaterials

The way acoustic coatings on submarine hulls can assist them remain quiet while also evading sonar detection from other marine vessels.

Stealth is as much about the art of not being heard as it is about not being seen. DST Group has engaged Professor Nicole Kessissoglou and Dr Paul Croaker of UNSW's School of Mechanical and Manufacturing Engineering to undertake fundamental research into the generation and propagation of flow-induced noise at sea and to study how this noise interacts with structures immersed in the flow. The research focus is to develop robust, well validated numerical techniques that can accurately predict underwater flow-induced noise.

High performance optical telemetry system for ocean monitoring

The goal of a recently completed UNSW CRC Project led by spin off company Zedelef, partnering with Thales, was to develop the next generation of distributed sonar arrays using UNSW-based photonics technologies and resulted in a successful demonstration of the technology.

Space

UNSW Space's current missions collaborating with Defence include Buccaneer, jointly developed with

Defence Science and Technology Group (DSTG), along with an additional two cubesat missions (M1 & M2) with the Royal Australian Air Force. These missions play a role in growing Australia's experience and space contribution, as well as building UNSW's capability to train for future Defence skills needs.

Key personnel

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The University of Queensland

The University of Queensland contact point:

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Research Partnerships

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Skills and capability

The University of Queensland (UQ) has numerous research and research collaborative strengths, with capability embedded in several faculties and institutes. The breadth extends from new lightweight materials for weapon systems and vehicles to vaccines; from hypersonic flight to legal issues impacting the autonomous combat.

UQ is a founding member of the Defence Materials Technology Centre and recently reached agreement with DST on a number of initiatives aimed at boosting Australia's hypersonics capability. UQ is Australia's leading knowledge transfer facilitator as measured by start-ups created and licensing revenue generated.

UQ's greatest concentration of relevant expertise is in the Intelligence, Surveillance and Reconnaissance, Space, Electronic Warfare and Cyber Security capability area outlined in the 2016 Defence White Paper. However, UQ is also particularly strong in underlying technologies that contribute across capability areas such as nanoscale engineering and in areas such as human factors that ensure our Defence personnel are operating at optimal effectiveness.

The University of Queensland
Australia

Research strengths

Hypersonics

Through UQ's Centre for Hypersonics, UQ collaborates with DST on the Hypersonic International Flights Research Experimentation (HIFiRE) program to investigate the fundamental science of hypersonic technology and its potential for next generation aeronautical systems. UQ's School of Mechanical & Mining Engineering (SMME) and its HyShot Group has enabled UQ to build advanced scramjet prototypes and undertake prolonged flight tests. UQ researchers conducted the first ever successful test flights of a scramjet in 2002.

CyberSecurity

UQ has established a world-class research group on cybersecurity within the School of Information Technology & Electrical Engineering. It focuses on understanding how security vulnerabilities arise in complex, interconnected software systems and developing tools to assist identify and analyse them. An emphasis on automation will ensure the tools are usable by non-specialist programmers.

Quantum and Photonic Sensing Technologies

UQ has strong research strengths in quantum and photonic sensing technologies, housed within the Australian Centre for Engineered Quantum Systems and the UQ Precision Sensing Initiative within the School of Mathematics and Physics. These next generation sensing technologies will impact future defence capabilities in position, navigation and timing, and situational awareness.

UQ is a founding member of the Defence Materials Technology Centre ...

Ethics and legal issues in Trusted Autonomous Systems

Work on ethics and legal issues in the development of trusted autonomous systems is a new collaboration involving UQ and UNSW beginning in the Defence CRC on Trusted Autonomous Systems (DTAS) in 2019. This collaboration will involve several post-docs and PhD students examining the legal and ethical issues posed by autonomous systems.

The University of Queensland

Microwave Technologies

UQ houses Australia's leading research group in microwave engineering. The research focus has been on electromagnetic imaging and sensing, in addition to building reconfigurable antennas and microwave devices for emerging on-the-move communication systems. The microwave engineering group has collaborative projects with EM Solutions; building flat panel reconfigurable antennas for low earth orbit satellites, CubeSats, drones, UAVs and other vehicles. It has begun work with EM Solutions on building autonomous satellite terminals for ubiquitous broadband communication.

Structural Health Management of Composite Materials

A long-term collaboration exists between UQ and the Aerospace Division of the Defence Science and Technology Group on the application of guided wave ultrasonics to detect and characterise damage in composite materials and structures. This has resulted in joint ARC Discovery projects, joint projects as part of the CRC for Advanced Composite Structures as well as DSTG funded Research Agreements. One major outcome was a joint book chapter in the 2016 AIAA Advanced Composite Materials and Structures reference text.

Corrosion performance and protection and modelling of material deformation at high strain rates

This collaboration builds on UQ's capability in the environmental performance and corrosion of light metals and is based on research partnerships with the Maritime Division, Defence Science and Technology Group. In partnership with Land Vehicle Survivability, Defence Science and Technology Group (funded as part of the Defence Science Partnerships Program) there is also collaboration on the modelling of material deformation at high strain rates.

Medical Countermeasures

Medical Countermeasures include vaccines, therapeutics and diagnostics for the protection of military and civilian personnel against chemical biological and radiological (CBR) threats, emerging infectious diseases and pandemics. UQ is currently involved in two projects with the DMTC in the medical

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

countermeasures area: "Rapid diagnosis of Microbial Infections without Culture" led by Dr Mark Blaskovich, Institute of Molecular Bioscience and "Phase 1 Clinical Trial of a novel Japanese encephalitis vaccine" led by Professor Roy Hall, School of Chemistry & Molecular Biosciences.

Research infrastructure

Hypersonic/Space Capabilities

- T4 – Free-piston driven shock tunnel
- X2 – Free-piston driven expansion tube
- X3 – Free-piston driven expansion tube
- Drummond tube/tunnel

Medical Countermeasures

- Terahertz laboratory
- Anechoic chamber (near- and far-field). The near-field antennae measurement system was the the first in an Australian university

Multidisciplinary material sciences

- *Composite manufacturing:* resin infusion, composite extrusion, small scale autoclave curing (two large ovens with internal dimensions W600 x D400 x H500), high temperature thermoplastic processing (compression moulding, injection moulding), high pressure resin transfer moulding, and reactive processing of thermoplastic composites
- *Material testing laboratory:* 5 Instron testing machines, including 2 electromechanical (EM) frame machines. Material testing can be performed using multiple configuration and in various environments, from elevated to cryogenic temperatures. ARAMIS measuring system, which consists of two 2448 pixel by 2050 pixel resolution cameras that can capture images at a frame rate up to 15 Hz. The ARAMIS software provides full calculation of 2D and 3D displacement and strain fields

Intelligence, surveillance, reconnaissance, electronic warfare, space and cyber

- iMotion biometric research suite being procured

Collaborations

Hypersonics

The pioneering HyShot and HIFiRE flight test programs involved DST, US Air Force, DARPA, Boeing, QinetiQ, JAXA and many university groups worldwide. Following HyShot the DST Applied Hypersonics Group was founded and conducted the successful HIFiRE Program with UQ and Boeing as key collaborators.

The 2019 establishment of the DST Eagle Farm complex, and the relocation there of UQ's X3 multi-mode shock tunnel creates Australia's largest hypersonic test facility, earmarked to become an international hub for collaborative aerospace research.

Airborne Imaging and Mapping

UQ's Remote Sensing Research Centre (RSRC) hosts Australia's national earth observation coordination body, Earth Observation Australia and conducts associated government research. This Centre is supported by state-of-the-art research infrastructure.

Human robot interaction

Significant collaboration with the Aerospace Division, Defence Science and Technology and UQ, UCSD and WPAFB. The project is a DST – US AFOSR grant, funded under the Trusted Autonomous Systems program. Robots are increasingly being included as team members in a range of cooperative team tasks, creating a need for advanced analysis methods to understand their interaction dynamics. The aim is to develop an Interactive Systems Toolkit incorporating novel qualitative and quantitative analysis techniques, to analyse open data sets from the fields of human-robot interactions and social neuroscience, and to develop robots that function as cooperative team members.

Quantum and Photonic Sensing Technologies

UQ has strong research strengths in quantum and photonic sensing technologies. UQ researchers collaborate with Defence and the Defence industry, including funding through the NGTF, AFOSR, ARO, Lockheed Martin, and Boeing.

The University of Queensland
Australia

Key personnel

Professor Matt Dargusch, School of Mechanical & Mining Engineering (SMME) and DMTC – Corrosion performance

Professor David Mee, SMEE – Hypersonic and Supersonic Flow

Professor Paul Meehan, SMME – smart machines, spacecraft systems and biological/human body processes, advanced manufacturing modelling

Professor Richard Morgan, SMEE – hypersonics

Professor Allan Paull, SMME – hypersonics

Professor Michael Smart, SMME – hypersonic aerodynamics, scramjets

A/Professor Martin Veidt, SMME – composite materials, applied mechanics

Professor Amin Abbosh, SMME – microwave technologies

Professor Janet Wiles, School of Information Technology & Electrical Engineering (ITEE) – human factors, human robot interactions, visualization and artificial intelligence

Professor Brian Lovell, ITEE – computer vision and pattern recognition, face recognition

Professor Pauline Pounds, ITEE – UAVs, aerial robot-object interaction

Professor Penny Sanderson, School of Psychology/ITEE/ School of Medicine – human factors

A/Professor Vaughan Clarkson, ITEE – Real time assessment of situational awareness

A/Professor Graeme Smith, ITEE – cybersecurity

Dr Mark Blaskovich, Institute for Molecular Biosciences, antimicrobial resistance

A/Professor Warwick Bowen, School of Mathematics & Physics – quantum and photonic sensing

Professor Andrew White, School of Mathematics & Physics – quantum information, quantum optics

Professor Stuart Phinn, Remote Sensing Research Centre – airborne imaging and mapping

Dr Rain Liivoja, UQ Law School – ethics and legal issues

The University of Sydney

The University of Sydney contact point:

A/Professor Eric Knight
Pro Vice Chancellor (Research – Enterprise & Engagement)

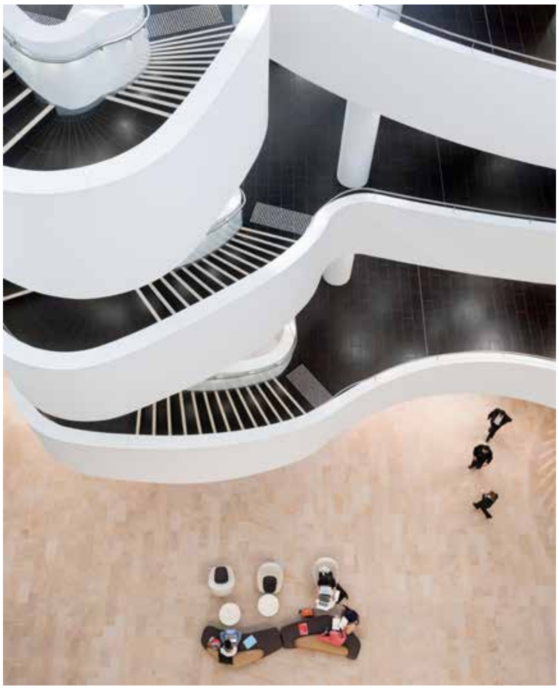
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Business Development Manager (Defence)

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Professor Duncan Ivison
Deputy Vice Chancellor (Research)

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Skills and capability

The University of Sydney has made a significant investment in multidisciplinary research – more than $1.5 billion over the past seven years and has a long-term relationship with the Australian Defence Force and Defence Science and Technology (DST) Group.

As one example, the university is working with Thales on breakthrough technology in underwater sensing and fibre laser sensors, recognising the pace of innovation is critical to world-leading new technologies and capabilities.

The university's core research facilities utilise the latest innovative technology across all disciplines. The Sydney Nanoscience Hub has specialised tools and processes to enable researchers and industry to make nanodevices and prototype new ideas. Currently, research is enabling development in optical chips, photonics, autonomous systems, surveillance, electronic devices and new quantum science and technology.

Research strengths

Trusted Autonomous Systems

The university's School of Aerospace, Mechanical and Mechatronic Engineering is developing lightweight unmanned aerial systems that combine vertical take-off with horizontal fixed wing flight for extended speed and endurance. These are supported by cutting-edge communication, control and sensor payloads. Using machine learning, The Australian Centre for Field Robotics is developing an automated acoustic surveillance system for the unmanned monitoring of Australian waters

Enhanced Human Performance

The adaptable cognition and decision-making research program at the Cognitive and Decision Sciences Lab collaborates with DSTO to investigate how people adapt to changing circumstances, and how this ability can be improved. Using virtual-reality simulation technologies they have developed a simulation to reliably measure the ability of individuals and potentially teams to be adaptable in the face of dynamic task demands

Additive Manufacturing

The Additive Manufacturing (AM) Group is transforming the way defence componentry is manufactured. This fundamental research cuts across all metal AM processes including large-scale processes that involve arc, plasma and laser, laser powder bed fusion, electron powder bed fusion, binder jet and metal jet processes. Enhancements to defence capability include the management of component run/repair/replace decision-making, component performance and functionality

Quantum Technologies

The Quantum Control Laboratory provides access to one of the world-leading quantum technologies – trapped atomic ions. It uses a combination of custom ultra-high-vacuum systems, precision stabilised lasers, high-stability radiofrequency oscillators, and flexible microwave control systems to measure the control, evolution, and interactions of quantum systems. Experiments and practically focused theory are enabling studies of fundamental

questions in quantum physics and the engineering of new quantum-enabled technologies from quantum computation to quantum sensing

Advanced sensors, photonics, and directed energy

The use of advanced photonic technologies is assisting build a high-sensitivity on-chip photonic enhanced radio frequency front-end system which addresses the current technology's limitations. Placed between a radar antenna and follow-on signal processing stages it improves detection of smaller, faster, smarter targets, as well as delivering enhanced operational intelligence, surveillance and reconnaissance.

The Nano Institute is developing single photon detectors that are compatible with semiconductor manufacturing and can be integrated on to ultra-compact photonic circuits. The research is translating this new class of single photon sensor prototypes into real-world applications to reduce complexity and improve portability and ease of operation.



Research infrastructure

The University of Sydney's core research facilities offer a range of related services to assist researchers with specialist applications. These centralised, shared facilities span faculties and serve as focal points of research activity.

The core research facilities bring together researchers from diverse disciplines, and provide the means to better manage and sustain high-end research infrastructure to conduct quality research.

The Research and Prototype Foundry

enables the development of optical chips, electronic devices and new quantum science and technology via outstanding lithography, etching, deposition and metrology. A purpose-built cleanroom provides an environment with extremely precise regulation of temperature, humidity, light and air composition, vibrations, and electromagnetic interference. The facility is recognised as one of the most advanced of its kind and houses many of the world's leading quantum physicists. For this reason, Microsoft chose to partner with the university for the advancement of quantum science.

The facility is recognised as one of the most advanced of its kind and houses many of the world's leading quantum physicists. For this reason, Microsoft chose to partner with the university for the advancement of quantum science.

Sydney Analytical and Sydney Microscopy and Microanalysis

has the most comprehensive and sophisticated material processing and characterisation capability available. It is fundamental to the development of strong, lightweight and durable materials and new materials with sophisticated properties.

The University of Sydney

The Sydney Informatics Hub

centralises our capabilities in data analytics, modelling, bioinformatics and high-performance computing with the Artemis supercomputer. This facility also houses capabilities in information/data engineering that power leading research in artificial intelligence, machine learning, cyber security and integrated/distributed digital platforms

The Advanced Manufacturing and Materials Processing Research Facility

has a major focus on additive manufacturing R&D. It is enormously relevant to defence industries and research priorities for the development and application of new materials, forward deployed manufacturing, consolidated parts prototyping, manufacturing and repair, integrated digital platforms, distributed systems security, artificial intelligence and automation



THE UNIVERSITY OF SYDNEY

The university also has leading multidisciplinary institutes of relevance:

The Australian Centre for Field Robotics (ACFR)

a fast-growing field robotics cohort with expertise in land, marine and aerial robotics as well as trusted autonomous systems, artificial intelligence and sensors development. The ACFR's ten year partnership implementing automation across Rio Tinto's mines is testimony to the level of expertise in this domain.

Sydney Nanoscience Hub

has specialised tools and processes to allow researchers and industry to make nanodevices and prototype new ideas.

Collaborations

The university has established research institutes and centres in partnership with government, industry and community partners.

Our engagement with the Department of Defence is extensive, covering research and education. We maintain long term collaborations with:

- Australian Army
- Air Force Office of Scientific Research
- US Army
- Microsoft
- QANTAS
- Thales

Autonomous Systems

The Aeronautical engineering group is collaborating with the Defence Innovation Hub on the AMSL Aero Autonomous Electric VTOL Aircraft. This aircraft provides the Australian Army with a high-speed autonomous logistics and casualty evacuation unmanned aircraft with vertical take-off and landing and 300 km/hr cruise speed. Multi-disciplinary expertise in aircraft and electric powertrain optimisation has allowed AMSL to push design boundaries providing an aircraft with unmatched performance. The project is being expanded to included full aircraft stability in collaboration with NSW Defence Innovation Network and a translation of the technology to civilian medical evacuation missions is under review.

The University of Sydney

Photonics

Integration of broadband microwave photonic frequency convertors is a collaboration with Harris Corporation, ANU and DST. It is to develop breakthrough microwave photonic processors with increased bandwidth and unprecedented RF signal processing and with massive reduction in size weight and power consumption. This would deliver vastly improved performance for use in phased-array antennas, satellite communications, electronic-countermeasures, radar processing and future fifth-generation wireless communications.

In collaboration with Plan Jericho the university is designing, fabricating and evaluating the performance of a new type of silicon-based single photon detector that … can be integrated on to ultracompact photonic circuits

In collaboration with Plan Jericho the university is designing, fabricating and evaluating the performance of a new type of silicon-based single photon detector that is compatible with traditional semiconductor manufacturing, without the need for cryogenic temperatures, and which can be integrated on to ultracompact photonic circuits. The project continues to leverage the technology and know-how that DST has been developing through its existing research and collaborative programs to develop and test advanced APD based single photon detector technologies.

Jericho Lab

The Jericho Lab – prototyped at Sydney – responds to military problems by bringing together the best minds in high-end science, design and technology to translate and accelerate leading-edge academic knowledge into defence capability. The Lab sits at the nexus of world leading scientific research, latest technology, creativity and entrepreneurship. The university is enabling capability integration of disruptive technologies, such as artificial intelligence and nanoscale photonics for the Air Force of the future.

The Lab is able to quickly develop and prototype capability enhancements to counter adversary combat technologies. It is where design becomes tangible, and where people share tools, resources and knowledge.

Marathon Targets

Established within the Australian Centre for Field Robotics, Marathon Targets sells robot targets to defence forces on four continents. Marathon robots are autonomous: the on-board software allows the robot to react the way that combatants might typically behave, using sensors to locate themselves and other targets while moving in and out of buildings on a live-fire all-terrain range.

Key personnel

Listed is a small sample of our expertise. Interest and inquiries regarding our work can be directed to our dedicated defence partnership team – contact details above.

Professor Simon Ringer Director, Core Research Facilities – Director of Core Research Facilities

Professor Michael Biercuk Director, Quantum Control Laboratory – Director of the Quantum Control Laboratory

Professor Xiaoke Yi Queen Elizabeth II Fellow, School of Electrical and Information Engineering – Leader Computing, Communication and Security, Australian Institute for Nanoscale Science and Technology

Professor Stefan Williams – Head of School, School of Aerospace, Mechanical and Mechatronic Engineering

A/Professor Cara Wrigley, Theme Leader, Energy and Environments, Australian Institute for Nanoscale Science and Technology

A/Professor Sabina Kleitman – Director of the Cognitive and Decision Sciences (CODES) Research Lab, School of Psychology

Dr Dries Verstratae, Senior Lecturer in Aerospace Design and Propulsion – School of Aerospace, Mechanical and Mechatronic Engineering

Professor Ben Eggleton, Director – Nano Institute and co-Director of the NSW Smart Sensing Network

The University of Western Australia

The University of Western Australia contact point:

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Skills and capability

The University of Western Australia (UWA) delivers multidisciplinary research, technology and business solutions. The university contributes to the national defence industry with leading strengths in marine engineering, human factors, automation and sensing.

Research strengths

UWA engages in a broad spectrum of research including radio astronomy and supercomputing, offshore engineering, marine science and comprehensive health research. Research areas include:

- Maximising capabilities in intensive environments (submarines) by understanding work design and human interface with technology to optimise performance

Host to the Perth USAsia Centre, a leading think tank focusing in geo-political issues, policy development and building strategic affairs.

THE UNIVERSITY OF WESTERN AUSTRALIA

- Host to the Perth USAsia Centre, a leading think tank focusing in geo-political issues, policy development and building strategic affairs
- Oceans expertise in in situ measurement, remote sensing, modelling of surface and internal waves, currents, sediment, morphology, and biogeochemical properties
- Research in turbulent flows, ocean circulation models, and laboratory work on transport and turbulent mixing within oceans
- Expertise relevant to defence includes the dynamics of large amplitude internal waves and the ocean response to tropical cyclone forcing
- Expertise and a significant research portfolio in floating vessel dynamics, ocean-structure interaction, offshore anchoring dynamics and geotechnical engineering
- Expertise in metocean dynamics and ocean forecasting, offshore fixed and floating structural engineering, hydrodynamics and structure interaction, and asset management
- In support of next-generation computational technologies, the Frequency and Quantum Metrology Research Group are leaders in precision measurement involving frequency, time and quantum systems
- Research includes miniaturised gravity gradiometer, interferometric EM gradiometer, microwave sensors and precision oscillators and clocks
- Advanced mathematical methods and numerical techniques to model the dynamics of quantum systems and investigate quantum algorithms
- Next generation technologies in remote operations, new materials for sensor fabrication, novel sensor architectures to sensor readouts and data analysis
- Development of new class infrared detection, imaging and multi/hyperspectral sensors, terahertz band sensing, optical/fibre systems, high sensitive magnetometers single-chip gas, chemical, pressure and temperature sensors

The University of Western Australia

- Designing and building hardware, electronics and software for almost 100 driving, walking, swimming/diving and flying robots
- Computer vision, particularly tools for machine learning in 3D biometric, RGB-D object segmentation and recognition, robot grasping and sub-sea ecology projects
- Signal and image processing, separation of acoustic signals using remote sensors, audio-visual data, and human speech recognition systems – for human machine interface
- Autonomous and electric drive systems, spanning DC, AC, and brushless systems, including motors, controllers, battery banks and charging systems
- Intelligent systems, artificial neural networks, biomedical engineering, control, digital signal processing, parallel and distributed computing, image processing, pattern recognition and software engineering
- Work design, resilience and performance related to the cognitive mechanisms that underlie human performance in safety-critical work contexts



- Prospective memory, situational awareness, human interaction with automated systems and error from interruptions, distraction and multitasking
- Research partner with RAN on submarine crews and the interface of new technology in future submarines to ensure optimal performance
- Development of new antibiotics with target components for virulence but not growth of bacteria, to reduce development of resistance. Extensive experience in containment level 3 work (PC3) and experience in Biosafety Level 2 and 3 work in both experimental and animal laboratories
- Injury management, spinal cord repair, soft tissue regeneration, enhanced cooling from hyperthermia, mechanisms of and delay of muscle fatigue
- Chemical measurement of stress, assessment tools for screening and early detection of mental health problems, remote health provision using wearables

Research infrastructure

- Australian National Fabrication Facility (ANFF) node at UWA is a state-of-the-art facility in infrared technology and micro electro mechanical systems fabrication processes for industry and broader research communities
- The Microelectronics Research Group runs a completely vertically-integrated sensor facility, from materials growth, through device design, fabrication and testing, to packaging and sub-system assembly
- The UWA Oceans Institute has facilities focused on oceanography, ocean dynamics, ecology, offshore and geotechnical engineering. It includes an Ocean Glider Facility with a fleet of autonomous, underwater ocean gliders
- Watermans Bay which is the Indian Ocean's first sea water facility for marine research with state-of-the-art laboratories

The University of Western Australia

- Pawsey Supercomputing Centre (UWA Visualisation), which operates multiple supercomputers, data-intensive machines and storage systems
- Centre for Microscopy, Characterisation and Analysis provides world-class microscopy and microanalysis facilities
- National Geotechnical Centrifuge Facility is a world leading geotechnical centrifuge facility working on a wide range of onshore and offshore geotechnical solutions
- Extensive Radio astronomy experience (ICRAR), the Gingin observatory which hosts tracking facilities and the Zadko telescope
- Ocean Glider Facility operates a fleet of autonomous, underwater ocean gliders to make sustainable measurements from the continental shelf and associated boundary currents
- A large pool of state-of-the-art field oceanographic and bioacoustic equipment available, including ocean sensors and laboratories
- The O-tube is a unique in-situ test facility for pipeline stability
- The Centre for Offshore Foundation Systems provides solutions to worldwide offshore foundation needs through sophisticated modelling and experimental facilities
- The National Geotechnical Centrifuge Facility is a world leading geotechnical centrifuge facility working on a wide range of onshore and offshore geotechnical solutions
- Woodside OceanWorks is an innovative space focused in bringing together industry and academia
- The Control Room Use Simulation Environment (Cruse) Lab
- Air Traffic Control Simulation
- Driving Simulator
- High level Physical Containment Level 2 (PC2) facilities
- Physical Containment Level 3 (PC3) animal facilities at the Biomedical Research Facility (BRF)

Collaborations

Key defence research collaborations include:

Counter Improvised Threats

As part of the inaugural DST Counter Improvised Threats Grand Challenge initiative UWA is developing high-tech sensors to detect bombs in public places. The sensors, which would be attached to drones, could detect residues of bomb-making chemicals on backpacks or suspicious packages at public gatherings such as sporting events.

Other research includes Optomechanical sensors and instruments and signal processing.

Human Factors

In collaboration with DSTO and the Royal Australian Navy, UWA has developed the CRUSE lab (Control Room Use Simulation Environment) to optimise the integration of a tactical information team to achieve decision superiority. The research aims to inform the design configuration of submarine hardware, software, and procedures (people), to create functionality that maximises team process, team cognition, and team performance.

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Medical Countermeasures

The Health and Medical Sciences group have a contract with DMTC looking at the characterisation of pathogens and discovery of novel medical countermeasures. The group has high containment PC2 facilities to handle Security Sensitive Biological Agents (SSBAs) Burkholderia pseudomallei and Coxiella burnetii phase II.

The University of Western Australia

Austal Smart Ship Initiative

UWA has partnered with defence prime contractor Austal. In response to increasing demand within the high-speed ferry market Austal increased focus on technology development. This collaboration is investigating smart technology options to develop current systems and capabilities to operate a vessel more efficiently.

Woodside Oceanworks

OceanWorks is a collaboration between Woodside FutureLab and UWA. Woodside FutureLab connects the best people in Western Australia to collaborate, create and innovate. It brings together researchers, entrepreneurs, subject matter experts and parallel leading industries.

Woodside RiverLab

The RiverLab – a collaboration between Woodside and UWA – is developing innovations in offshore engineering via research, education and outreach. RiverLab brings together researchers from diverse disciplines, with state-of-the art equipment, to enable unique field measurements and experiments in the Swan River.

Key personnel

Professor Mike Tobar – Faculty of Engineering & Mathematical Science

Professor Lorenzo Faraone, Head, Microelectronics Research Group – Faculty of Engineering & Mathematical Sciences

Professor Brett Nener, Microelectronics Research Group – Faculty of Engineering & Mathematical Sciences

Professor Peter Quinn, Director – International Centre for Radio Astronomy Research

Professor Mark Reynolds, Head of School – Faculty of Engineering & Mathematical Sciences

Professor Dilusha Silva, Microelectronics Research Group – Faculty of Engineering & Mathematical Sciences

Professor Mohammed Benammoun, Computer Science and Software Engineering – Faculty of Engineering & Mathematical Science

Professor Adrian Keating, Microelectronics Research Group – Faculty of Engineering & Mathematical Sciences

Professor Chari Pattiaratchi, Oceans Institute – Faculty of Engineering & Mathematical Science

Professor Simon Farrell, Business School – Faculty of Arts, Business, Law and Education

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A/Professor Shayne Loft, Deputy Head of School of Psychological Science – Faculty of Science

A/ Professor Troy Visser, School of Psychological Science – Faculty of Science

A/Professor Tim Sercombe, Head of School of Engineering – Faculty of Engineering & Mathematical Science

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A/Professor David Coward, Gravitational Wave Discovery – Faculty of Engineering & Mathematical Science

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